Applied Membrane Technology

Hollow Fiber Membrane Based Technology to Remove VOCs from Nitrogen (N_2) or Air Streams

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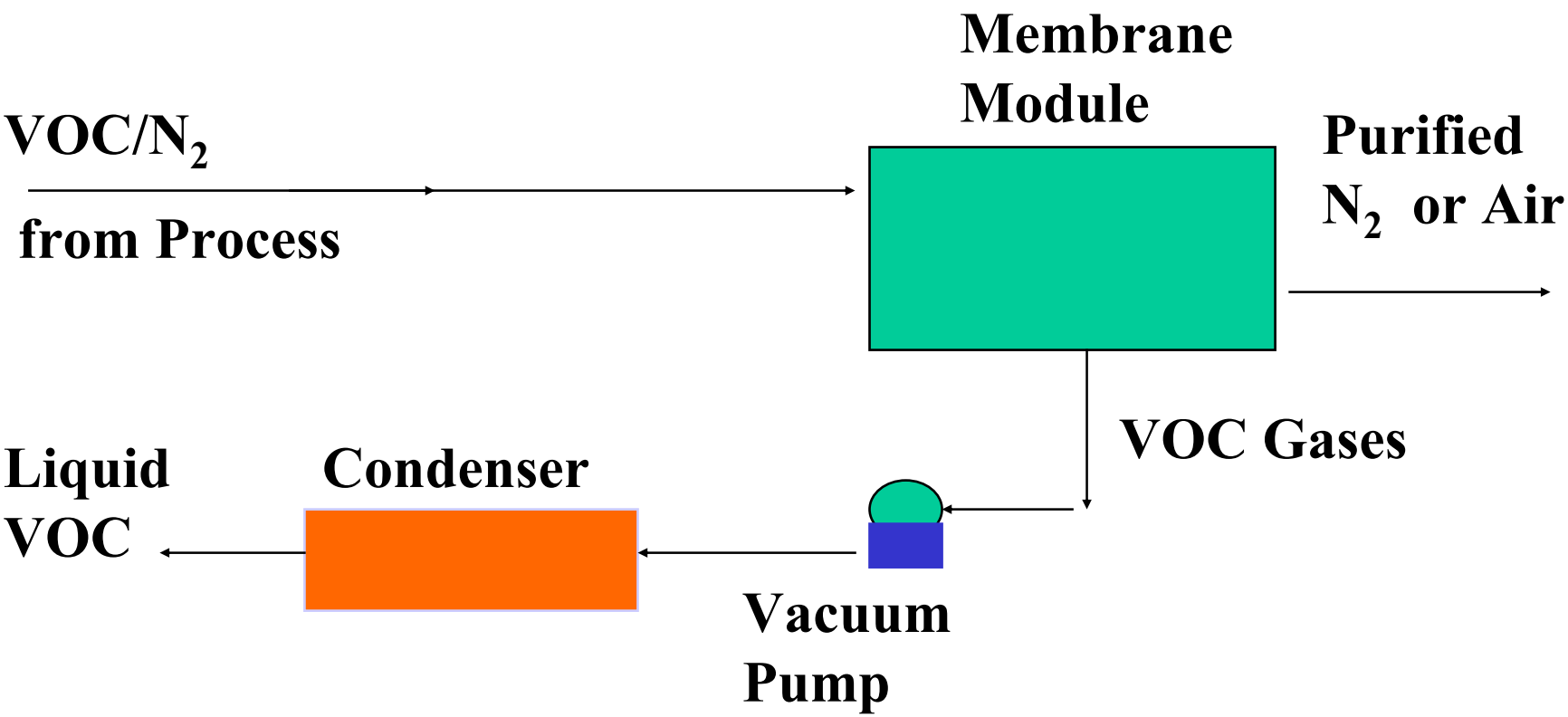
Key Features/Benefits of VOC-R^3 System
Removal – Recovery - Reuse

- **98 %+ removal & solvent recovery potential**
- **Effective both for batch & continuous processes**
- **Suitable for steady/unsteady flow processes**
- **Compact devices**
- **Point of use**
- **Moderate capital cost**
- **Low operational cost**
- **No fire explosion risk**

AMT VOC-R^3 Technology

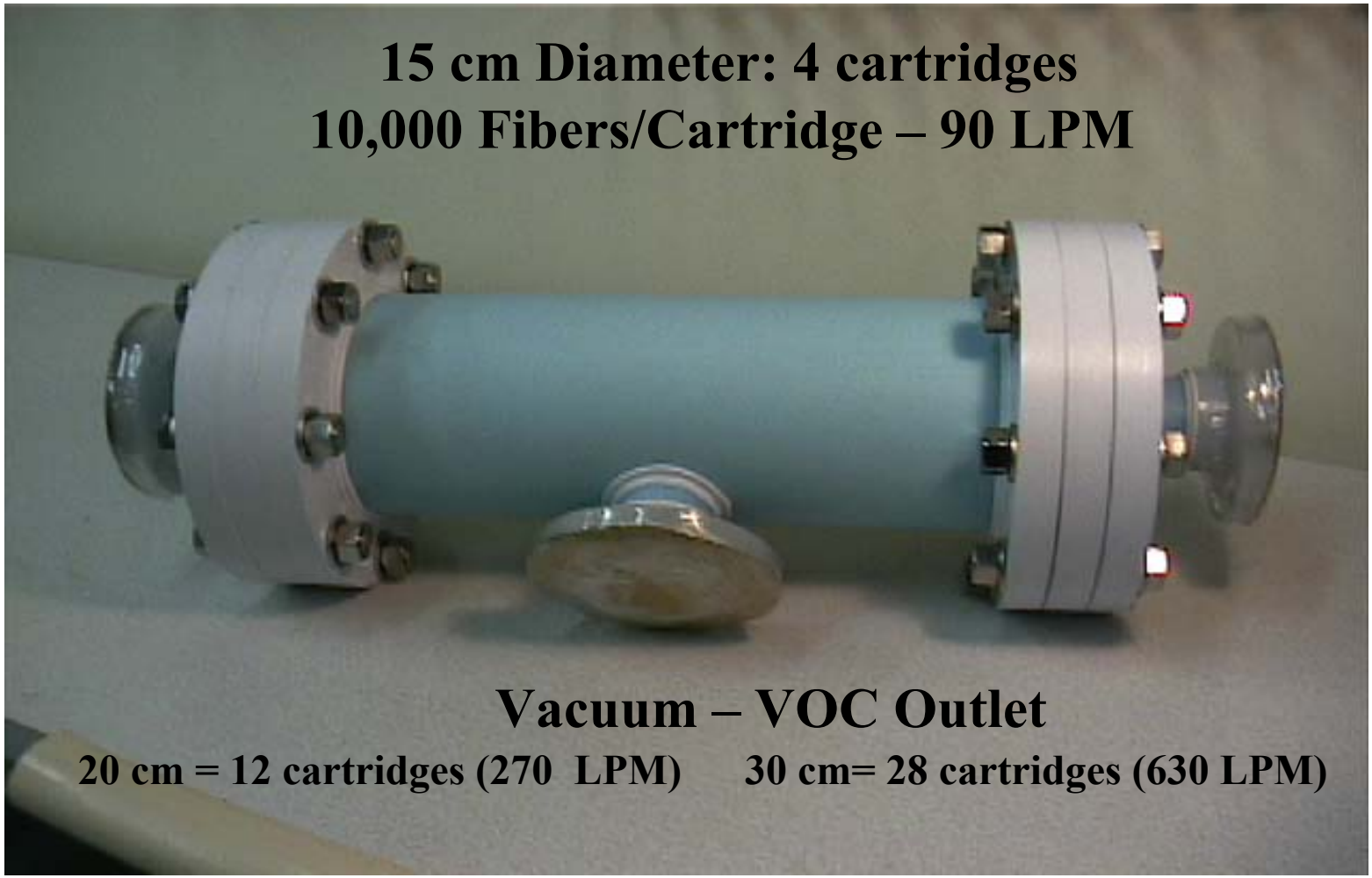
New Technology is protected by U.S. /European Patents



VOC – R^3 System Description

- **Microporous hydrophobic polypropylene hollow fibers with an ultra-thin plasma polymerized silicone skin**
- **Thousands of hollow fibers are bundled in a cartridge, which are part of the VOC – R^3 separation module**
- **VOC-containing gas mixture is passed through the bore of the fibers. By applying a vacuum to the shell-side of the hollow-fiber cartridge the VOCs are separated from the feed stream. Molecules such as oxygen and nitrogen are much slower permeators and are rejected by the membrane film and vented to the air.**
- **The permeate is condensed to recover and to reuse the VOCs; the non-condensed are returned to the feed.**

VOC – R^3 Separation Module



Membrane Technology Comparison

AMT Hollow Fibers vs. Flat Films

AMT Key Advantages:

- **Multiple higher surface area allows compact cartridge designs.**
- **Lower pressure difference requirements eliminate the need for a compressor (operational and capital cost savings, compact design, safer).**

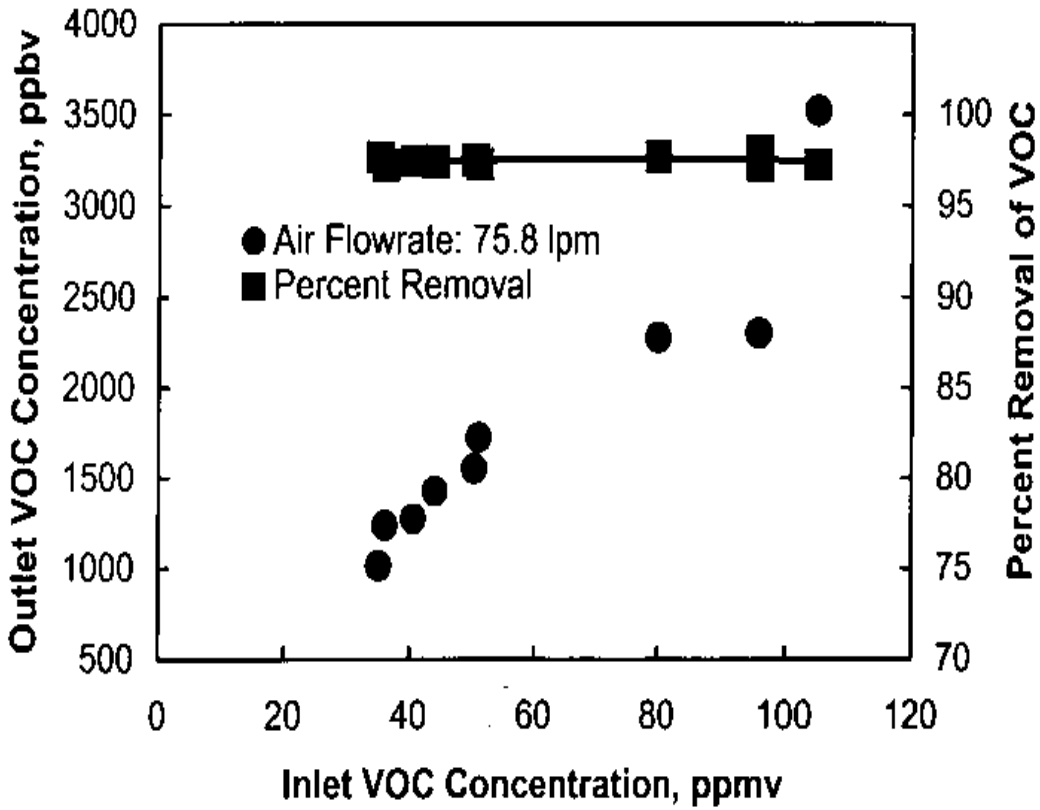
VOC Removal Performance

Paint Box Exhaust Stream - NASA

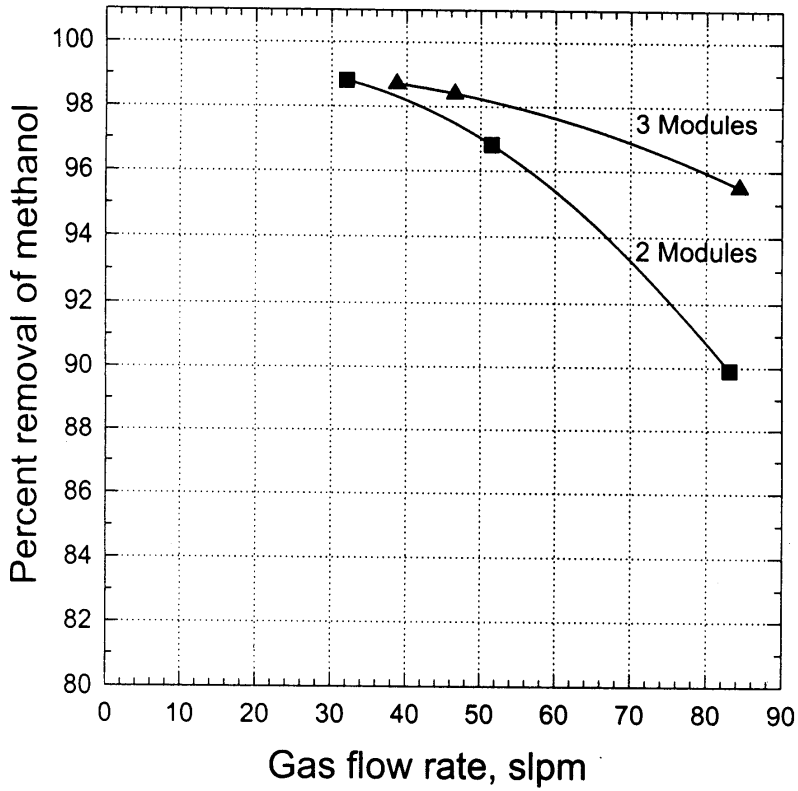
- **VOC reduction >97%**

  (fixed air flow rate and membrane surface area)

- **Consistent high VOC reduction performance despite inlet VOC concentration changes**



- **RESULTS**
  - **Methanol**
  - **reduction > 98%**
  - **Reduction level dependi on gas flow rate and membrane surface area/ of modules**



Methanol vapor removal at different feed gas flow rates.

Membrane area in each module: ~4 m^2

■ 2 modules; methanol concentration in feed gas: 13.0 ± 1.2%
▲ 3 modules; methanol concentration in feed gas: 14.0 ± 4.0%

Competing Technologies

Technology	Capital Costs	Operation Costs	Safety	Recovery
Membrane Separation	Moderate	Low	High	Yes
Incineration	Moderate To High	High	Low	No
Adsorption	Moderate To High	High	Low	No
Cryogenic Condensation	Moderate To High	Moderate	Moderate To Low	Yes